WHAT IS CLAIMED IS:

1. A microfludic device comprising:

a microfluidic flow channel formed in a first layer;

a first microfluidic control channel formed in a second layer adjacent to the first layer, the first microfluidic control channel separated from the microfluidic flow channel by a first deflectable membrane; and

a second microfluidic control channel adjacent to the first microfluidic control channel and separated from the first microfluidic control channel by a second deflectable membrane

2. The microfludic device of claim 1 wherein the first layer underlies the second layer.

3. The microfludic device of claim 1 wherein the first layer overlies the second layer.

4. The microfludic device of claim 1 wherein the second microfluidic control channel is formed in the first layer and does not intersect with the microfluidic flow channel.

5. The microfludic device of claim 1 wherein the second microfluidic control channel is formed in a third layer adjacent to the second layer.

6. The microfludic device of claim 1 wherein:

the first microfluidic flow channel comprises a network of flow channels;

the first microfluidic control channel comprises a branched network of channels sharing a common inlet and having widened portions; and

the second microfluidic control channel comprises a network of channels having separate inlets and also having widened portions.

7. The microfludic device of claim 6 wherein:

a number of branches of the first control channel network equals a number of the flow channels, each first control channel branch including only one widened portion at a corresponding flow channel branch; and

the channels of the second control channel network are arranged in a multiplexor configuration, thereby defining an inverse multiplexor structure.

8. The microfludic device of claim 6 wherein:

a number of branches of the first control channel network is fewer than a number of the flow channels and have widened portions arranged in a first multiplexor configuration; and

a number of channels of the second control channel network is fewer than a number of the flow channels and have widened portions arranged in a second multiplexor configuration, thereby defining a cascaded multiplexor structure.

9. The microfludic device of claim 6 wherein at least one of the first control channel network and the second control channel network comprise a first stage having at least $x\log_x n$ control channels, where n is the number of flow channels and x is an integer greater than 2.

10. The microfludic device of claim 9 wherein the at least one of the first control channel network and the second control channel network further comprises a second stage having at least $x\log_x n$ control channels, where n is the number of flow channels and x is an integer greater than 1.

11. The microfludic device of claim 1 further comprising a third microfluidic control channel adjacent to the second microfluidic control channel and separated from the second microfluidic control channel by a third deflectable membrane.

12. The microfludic device of claim 11 wherein:

the first microfluidic flow channel comprises a network of flow channels;

the first microfluidic control channel comprises a first branched network of channels sharing a first common inlet and having widened portions;

the second microfluidic control channel comprises a second branched network of channels sharing a second common inlet and also having widened portions; and

the third microfluidic control channel comprises a network of channels having separate inlets and also having widened portions.

13. A method of controlling flow in a microfluidic structure, the method comprising:

applying pressure to a control channel of a first control channel network separated from an adjacent flow channel by a first membrane, such that the first membrane is deflected into the flow channel;

while maintaining pressure in the first control channel network, applying a pressure to a control channel of a second control channel network separated from the first flow channel network by a second membrane, such that the second membrane is deflected into and seals the control channel of the first control channel network; and

while maintaining pressure in the control channel of the second control channel network, releasing pressure in the first control channel network such that the first membrane remains deflected into the flow channel.

14. The method of claim 13 wherein the first control channel network overlies the flow channel such that the first membrane is deflected downwardly into the flow channel.

15. The method of claim 14 wherein the second control channel network overlies the first control channel network such that the second membrane is deflected downwardly into the control channel of the first control channel network.

16. The method of claim 14 wherein the second control channel network underlies the first control channel network such that the second membrane is deflected upwardly into the control channel of the first control channel network.

17. The method of claim 13 wherein the first control channel network underlies the flow channel such that the first membrane is deflected upwardly into the flow channel.

18. The method of claim 17 wherein the second control channel network underlies the first control channel network such that the second membrane is deflected upwardly into the control channel of the first control channel network.

19. The method of claim 17 wherein the second control channel network overlies the first control channel network such that the second membrane is deflected downwardly into the control channel of the first control channel network.

20. The method of claim 13 wherein releasing pressure in the first control channel network causes another membrane between the first control channel network and a second flow channel to deflect out of the second flow channel.

21. The method of claim 20 wherein the second control channel network comprises a multiplexor, thereby allowing all but one of the flow channels to be closed at the same time.

22. The method of claim 21 wherein the first control channel network comprises a second multiplexor, thereby allowing a fewer number of control channels of the second control channel network to control movement of fluid through the flow channels.

23. A microfabricated structure comprising:

an array of storage locations defined by a first plurality of parallel flow channels orthogonal to a second plurality of parallel flow channels;

a network of control lines adjacent to the storage locations to define deflectable valves for isolating the storage locations;

a first multiplexor structure configured to govern flow through the first plurality of parallel flow channels; and

a second multiplexor structure configured to govern flow through the second plurality of parallel flow channels.

24. The microfabricated structure of claim 23 wherein:

the first plurality of parallel flow channels and the second plurality of parallel flow channels are formed in the same elastomer layer to define the array of storage locations at the intersection of the first plurality of flow channels and the second plurality of flow channels; and

the first and second multiplexors are formed in the same elastomer layer as the control channel network

25. The microfabricated structure of claim 24 further comprising a second network of control channels formed in the elastomer layer of the plurality of flow channels overlying or underlying the first multiplexor.

26. The microfabricated structure of claim 24 further comprising a plurality of bus lines adjacent to the first plurality of flow channels to permit selective access to the storage locations.

27. The microfabricated structure of claim 23 wherein:

the first plurality of parallel flow channels and the second plurality of parallel flow channels are formed in different elastomer layers;

the array of storage locations is defined by a chamber formed in an intervening elastomer layer between the first and second plurality of flow channels; and

one of the first plurality of parallel flow channels is in vertical fluid communication with a chamber through a first one-way valve; and

the chamber is in vertical fluid communication with one of the second plurality of parallel flow channels through a second one-way valve.

28. The microfabricated structure of claim 27 wherein the one-way valves comprise a elastomer membrane configured to rest on a seat and to deflect in one vertical direction only.

29. The microfabricated structure of claim 28 wherein the one-way valves are configured to deflect upward.

30. A microfabricated one-way valve comprising:

a first elastomer layer comprising a vertical via portion and a seat portion; and

a second elastomer layer comprising a flexible membrane having an integral end and a nonintegral end, the nonintegral end in contact with the seat portion and configured to be deflected into a second vertical via portion.

31. The microfabricated valve of claim 30 wherein the first elastomer layer overlies the second elastomer layer.

32. The microfabricated valve of claim 30 wherein the first elastomer layer underlies the second elastomer layer.

33. The microfabricated valve of claim 30 wherein the second vertical via portion is defined by a third elastomer layer in contact with the second elastomer layer.

34. A microfluidic device comprising:

an elongated first flow channel;

a control channel overlapping the elongated first flow channel to define a first valve structure, the valve structure configured to deflect into the elongated first flow channel to define first and second segments of the first flow channel;

a second flow channel in fluid communication with the first segment; and

a third flow channel in fluid communication with the second segment.

35. The microfluidic device of claim 34 further comprising:

a second valve actuable to selectively isolate the first segment from the second flow channel; and

a third valve actuable to selectively isolate the second segment from the third flow channel.

36. The microfluidic device of claim 34 further comprising:

a heterogeneous sample present in the first elongated flow channel; and

a reactant present in at least one of the second and third flow channels.

37. A method of isolating elements of heterogeneous sample, the method comprising:

flowing a sample comprising heterogeneous elements down a first elongated microfluidic flow channel;

actuating a first valve overlying the first elongated flow channel to define first and second segments, such that the first segment contains a first element of the heterogeneous sample and the second segment contains a second element of the heterogeneous sample.

38. The method of claim 37 further comprising diluting the heterogeneous sample to ensure that only one element of the sample is present in the first and second segments.

39. The method of claim 37 further comprising delivering a reactant to the first segment to react with the first element of the heterogeneous sample.

40. The method of claim 39 further comprising delivering the reactant to the second segment to react with the second element of the heterogeneous sample.

41. The method of claim 37 further comprising recovering the combined reactant and first sample element.

42. A microfluidic device comprising:

a selectively-addressable storage location defined within elastomer material;

a first flow channel in selective fluid communication with the storage location through a valve; and

a second flow channel in selective fluid communication with the storage location through a second valve.

43. The microfluidic device of claim 42, wherein the first and second flow channels are coplanar with the storage location.

44. The microfluidic device of claim 43, wherein:

the storage location is defined by an intersection between a third and a fourth flow channel; and

the second flow channel comprises a bus line parallel to the third flow channel.

45. The microfluidic device of claim 42, wherein the first and second flow channels are in fluid communication with the storage location through a vertical via.

46. The microfluidic device of claim 45 wherein:

the first flow channel is in fluid communication with the storage location through a first one-way valve; and

the storage location is in fluid communication with the second flow channel through a second one-way valve.

47. The microfluidic device of claim 46 further comprising:

a first control channel network adjacent to the first flow channel to define a first multiplexor configured to control pressure within the first flow channel; and

a second control channel network adjacent to the second flow channel to define a second multiplexor configured to control pressure within the second flow channel.

48. A method for selectively storing and recovering a material in a microfluidic device, the method comprising:

providing a chamber defined within an elastomer material;

selectively flowing a material into the chamber through a first valve in a first flow channel; and

selectively flowing the material from the chamber through a second valve in a second flow channel.

49. The method of claim 48 wherein:

the material is flowed into the chamber through the first flow channel disposed on the same plane as the chamber; and

the material is flowed from the chamber through the second flow channel disposed on the same plane as the chamber and the first flow channel.

50. The method of claim 48 wherein:

the material is flowed into the chamber through the first flow channel disposed one of beneath or above the chamber; and

the material is flowed from the chamber through the second flow channel disposed on the other of beneath or above the chamber and the first flow channel.

51. The method of claim 50 wherein:

the material is flowed into the chamber through a first one-way valve; and

the material is flowed from the chamber through a second one-way valve.

52. The method of claim 48 wherein the material comprises an optically absorbing material, such that the microfluidic device functions as a display.

53. The method of claim 48 wherein the material comprises a cell, such that the microfluidic device functions as a cell pen.